

## Editorial

### Schizokinesis and Fractional Conditioning

W. HORSLEY GANTT

*Pavlovian Research Laboratories, V. A. Hospital, Perry Point, Md.;  
Johns Hopkins Medical School*

PHYSICAL SCIENCE follows a pattern laid down in the theoretical scheme of Descartes and the experimental method of Galileo. Essentially this method is based upon the careful and controlled quantitative simultaneous measurement of two things. It is possible thus to see and chart through the system of Cartesian coordinates how one thing changes as another changes. This method is especially successful when it deals with items such as the velocity of a freely-falling body in terms of distance and time.

Biological science follows this pattern of the physical sciences. However, when we deal with the living organism—a continually-fluctuating universe—our problem is tremendously complicated. Many changes occur in the organism simultaneously, and most of them are interrelated, but in order to comprehend a subject, the human mind must generally consider only two things at a time. Such kinds of measurements result in clean statistical data which can be manipulated and forced into mathematical formulae.

In biology we have the difficult choice of measuring simultaneously and precisely one or two things or including more items not always related.

In the study of behavior by the conditional reflex method, we generally employ gross muscular movement, salivary secretion, cardiovascular functions (heart rate, blood pressure, stroke volume), and respiratory rate. Our laws of behavior are usually formulated from considering only one of these functions. If these functions do not fluctuate harmoniously, our conclusions may be completely erroneous; *we may be observing a non-fluctuating system and miss the big changes elsewhere*; our deductions may be valid for the given system and completely invalid for the organism. This fallacy we have seen by adding the cardiovascular-respiratory system to the salivary-motor system.

By including three or more functions, we may get an entirely different picture of the individual from that obtained by looking at only two items. As an index for behavior, Pavlov used chiefly salivary and gastric secretions, while American psychologists have been concerned mostly with gross skeletal movements in space.

Our studies over the last third of the century have included salivary secretion, motor activity, respiratory functions and, since 1940, cardiovascular functions.

I should like to call attention to the principles of fractional conditioning and schizokinesis which have arisen from the simultaneous measurement of several physiological functions. Most agents used as stimuli evoke a number of physiological responses in the organism. Thus the ingestion of food is preceded by many movements and is followed by numerous secretory activities, cardiovascular and metabolic changes, e.g., atropine produces tachycardia, suppression of secretion, etc., adrenalin causes hyperglycemia, increased blood

pressure, muscular tremors. When we look at the various responses to a single agent we may find that some of these are capable of becoming conditional reflexes and others will never become conditional reflexes.

This adaptation to an agent through conditioning of only some aspects of the UR may be considered FRACTIONAL CONDITIONING. The term was employed by Hilgard and Marquis in 1939 and later by Kimble in a somewhat different sense from the way that I use it. A long series of studies in our laboratories has revealed some of the principles responsible for conditioning.

The explanation which emerges from our work concerns the mechanism of how the unconditional action is produced; if the central nervous system is involved in the production of the action it may become a conditional reflex, but if the action is produced directly and solely by the peripheral activity of the stimulus without mediation through the c.n.s. it has not been possible to use it as a basis of a conditional reflex. Thus gastric secretion to food in a hungry dog is easily conditioned but the same secretion produced by histamine injection (acting directly on the gastric glands) is not conditionable. The results of "feedback" alone, a kind of reverberation in the nervous system, are not sufficient for conditioning.

Thus the tachycardia produced by atropine, though it may have a representation in the central nervous system through the sensory nerves, is not sufficient for conditioning since it does not precede but follows the stimulation by atropine. The time difference may be in minute fractions of a second, but this time difference is crucial. The law of backward conditioning might possibly be operating, but relative to these experiments it has never been tested adequately.

Fractional conditioning appears to be an absolute phenomenon. There is, however, another principle having to do with a relative rather than an absolute characteristic of conditioning, viz., the comparative speed, intensity and stability of those functions which can become conditional reflexes. This latter property is called *schizokinesis*. If we study simultaneously heart rate, respiration, motor activity, and salivary secretion in the case of a food stimulus, we see that the changes in heart rate become a conditional reflex after one or a few reinforcements with food, while the salivary and the motor components may require many days of reinforcements. The cardiovascular response and the respiratory response generally become conditioned together, whereas the somatic muscular and the salivary responses are usually parallel and take longer to form. Paradoxically, the cardiovascular conditional reflexes are usually, though not always, much more stable than the salivary and motor reflexes and much more resistant to extinction. This difference in the degree and duration of those functions which are conditionable is what we call *schizokinesis*—a split in the development of the different aspects of the conditional reflex.

At present it is not possible to elucidate the teleology at the basis of *schizokinesis*—we do not know enough about what constitutes the harmonious working of the organism. From the point of view of expenditure of energy it is inefficient for one function (the cardiac) to go on working and reacting to a past stimulus no longer active while the muscular and secretory systems have adapted. In the broadest sense, *schizokinesis* refers to a general lack of harmonious adaptation in the organism. We know of such failures to adapt inherent in the biological structure which can lead to pathology—disease and ultimate death. The puzzle is still to be solved; there are some who think that death results from a kind of *schizokinesis* among the various organs leading to amyloid deposits in many tissues, a result of a battle among organs.

In connection with the contrasts of conditioning in the various systems, Schoenfeld writes to me (letter of 31 July 1967, Wm. N. Schoenfeld): "... there is no solid reason for anyone to take offence or to challenge the actual

substance of the idea you have termed *schizokinesis* and its related *fractional conditioning*. In any behavioral training procedure where several different responses are measured simultaneously, it is commonplace to find (as you have been emphasizing) that the different responses do not show the same time course, whether of strengthening or weakening, as training proceeds. And where even a single response is being observed, when different aspects of that response are measured, such as latency or magnitude, each measure may be observed to take a different course over time as training proceeds. No one seems ever to have proposed a tenable reason either as to why these measures *should* go together, or why they should *not*. I share your feeling that there are some important and subtle problems involved in these observations; . . .

" . . . The foregoing facts have rather wide validity in behavioral science. They have been known for many years in areas such as the measurement of sensory thresholds both in man and in lower animals. For example, the visual brightness threshold obtained for a single organism will vary depending upon what particular response (whether verbal report, or GSR, or the like) is chosen as the indicator. If many indicator responses are measured simultaneously, then they will reach stated criterion strengths at different stimulus values, thus yielding different thresholds.

"In truth, it sometimes seems to me that the validity of these observations extends even to the physical-chemical sciences. Take any physical-chemical process or system you please, subject it to some energy transfers, measure several aspects of the system simultaneously, and I think it would be observed that the time courses of those different measures will not be identical. But I hesitate to press along this line—not because the matter is unimportant, but because I think the problem may take on a different guise when those cases are dealt with."

The Russian work following Pavlov generally has not been especially analytical concerning principles of conditioning, with the exception of that on ablation of parts of the nervous system. Bykov in his book, *The Cortex and the Internal Organs*, has tended rather to show that practically all functions of the organism can become conditional reflexes. It is true, however, that Bykov spoke of the necessity of a stimulus "adequate to the animal's receptors," and of a "polyneuronal chain," and he investigated the roles of hormones and of the nervous system, but he left uninvestigated both fractional conditioning and schizokinesis as we understand them.

Both of these phenomena, fractional conditioning and schizokinesis, require for their understanding much more investigation. At present we see them only in their broad outlines as frontiers. In fractional conditioning, why is the renal function of diuresis apparently absolutely resistant to conditioning (work of Corson, Dykman, Reese, Watt, Livingston, Gantt); why is the stimulation of the cranial end of the vagus apparently not conditionable (Andrus et al.)? The underlying principles up to now have not been revealed.

In the present stage of our studies on schizokinesis we must be content to collect, classify, and compare the various aspects of the conditional reflex, the times of their appearances, their stabilities, their resistances to extinction. The mechanism and understanding of the phenomena must wait upon an examination of the data collected from many different experiments.